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Vegetation Response to Helicopter Logging and Broadcast Burning in Douglas-fir Habitat Types at Silver Creek, Central Idaho

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RESEARCH SUMMARY

Vegetal response of shrubs and herbs (forbs and graminoids) was measured on 12 plots in the *Pseudotsuga menziesii/Spiraea betulifolia* and *Pseudotsuga menziesii/ Physocarpus malvaceus* habitat types (h.t.) at the Silver Creek Study Area in central Idaho. The plots were located throughout three designated cutting units and were surveyed prior to harvesting in summer 1976. Shrub frequency, cover, and height were measured as well as herb cover and frequency. The cutting units were logged and helicopter yarded during fall 1976. One cutting unit was broadcast burned in December 1976 while the other two were broadcast burned in February 1977. Based on the Ryan-Noste fire severity rating (Ryan and Noste 1985), the burning in December was a 3-M while the burning in February was a 2-M. Plots were remeasured 1, 2, 5, and 10 years after the disturbance. Comparisons of unburned and burned plots in the 2-M burned cutting units showed little difference in the recovery of most major shrub and herb species. Vegetal composition after 10 years was essentially the same as the original with only a few exceptions. One shrub, *Symphoricarpos albus*, increased throughout the cutting area, though the increases were the same on unburned and burned plots. Herb composition changed slightly in that annuals and short-lived perennials increased on most of the cutting area. Two forbs, *Arnica cordifolia* and *Lathyrus nevadensis*, decreased throughout the cutting unit as a result of the treatment.

Vegetation on the 3-M burned plots was altered from the original. Unburned plots in the 3-M burned cutting unit were similar to both unburned and burned plots in the 2-M burned cutting unit. However, vegetation on 3-M burned plots was dominated by *Ceanothus velutinus* after 10 years even though little was present in the predisturbance community. Two other species, *Physocarpus malvaceus* and *Carex geyeri*, appeared to have been retarded by the more severe burning.

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INTRODUCTION

Helicopters are often used to remove logs from steep harvest areas with unstable soils. This harvesting method reduces the need for movement of machinery and logs over the site, thereby decreasing the amount of site and soil disturbance. Consequently, helicopter logging has little physical impact on the soil and understory vegetation. Dyrness (1972) found that only 20 percent of the soil surface in a balloon-logged clearcut was "slightly" or "deeply" disturbed and that bare mineral soil was exposed over only 6 percent of the area. However, while minimal soil disturbance reduces erosional hazards (Megahan 1974) silviculturists are concerned that the lack of soil disturbance will retard conifer regeneration because bare mineral soil is a preferred seedbed for many conifer species. Large amounts of residual debris can also inhibit conifer regeneration and increase the fire hazard (Bjornsen and Mustian undated). Silviculturists are faced with the dilemma of how to prepare a site for regeneration and to reduce slash, without negating the use of a low-impact yarding system. Machine scarification, though often used in central Idaho, is not compatible with helicopter logging. However, prescribed burning is an alternative. Little is known, though, about the effects of broadcast burning on the dry forest environments of central Idaho. Lyon (1971) conducted a study of vegetal development following broadcast burning in central Idaho on a moist forest habitat and found that most species on the site survived the burning, though the composition of the vegetation was altered. Many researchers (Crane and others 1983; Dyrness 1973; Lyon and Stickney 1976) concluded that the postburn communities are greatly influenced by the preburn community because many species are capable of resprouting. Lyon and Stickney (1976) found that most species that survive burning will reestablish within the first year of the disturbance. Total cover of vegetation often exceeds preburn levels within 8 to 10 years following the burning (Dyrness 1973), though the composition is often altered. Results from Lyon's (1971) study were similar; total understory cover was approaching the preburn levels and would have exceeded it except for the slow recovery of one major species. However, Merrill and others (1982) caution that effects of burning on vegetation in drier environments may be different than the effects in more moist environments. Most of the vegetation response studies have been conducted in forest environments that are much more moist than many of the forest environments in central Idaho, and the response may not be the same.

STUDY AREA

The study is in west-central Idaho 50 miles north of Boise, ID, in the Silver Creek Study Area on Control Creek, a tributary of Silver Creek (fig. 1). Control Creek drains 404 acres of Idaho batholith, an area of steep slopes overlain with highly erodible granitic rock (Clayton and Kennedy 1985). The soils are coarse textured, lack cohesion, and are very erodible following disturbance. Slope angles within the study area range from 18 to 55 percent. Elevation ranges from 4,650 to 5,850 ft. The mean annual maximum temperature from 1976 to 1985 was 52 °F while the mean annual low temperature was 30 °F. The average annual precipitation over the 10 years was 36 inches, most of which fell from October to March. Only a small amount (average 1.4 inches) fell during June, July and August. Two abnormally dry periods occurred during this 10 years. The first was from September 1976 through April 1977 when precipitation levels were only 33 percent of normal (unpublished data on file at the Forestry Sciences Laboratory, Boise, ID). The second dry period occurred from December 1985 through August 1986 when precipitation levels were only 56 percent of normal.

Two habitat types (h.t.) as described by Steele and others (1981) dominate in the Control Creek drainage: *Pseudotsuga menziesii / Spiraea betulifolia* h.t., *Pinus ponderosa* phase and *Pseudotsuga menziesii / Physocarpus malvaceus* h.t., *Pinus ponderosa* phase. The *Pseudotsuga menziesii / Spiraea betulifolia* h.t. occurs in drier areas of the Douglas-fir zone than does the *Pseudotsuga menziesii / Physocarpus malvaceus* h.t. Climax understory vegetation in the *Pseudotsuga menziesii / Spiraea betulifolia*

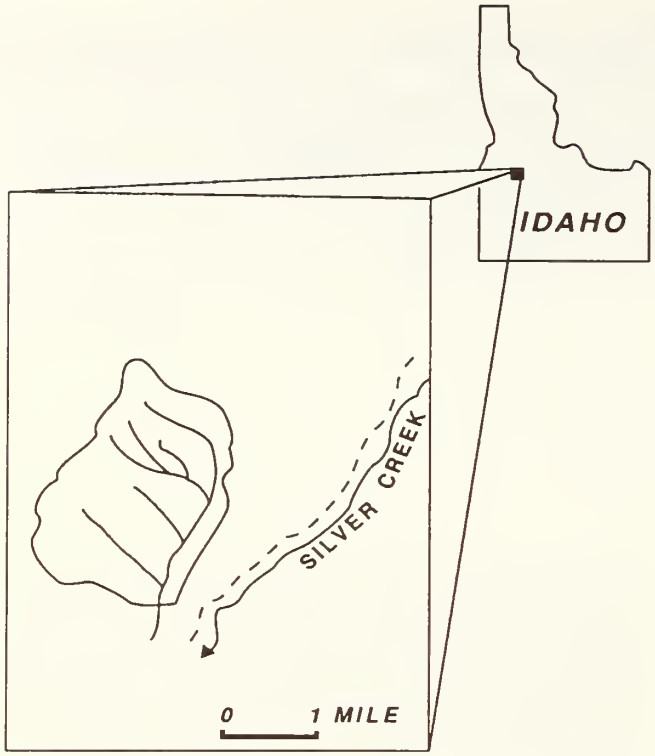

Figure 1—Location of Silver Creek Study Area.

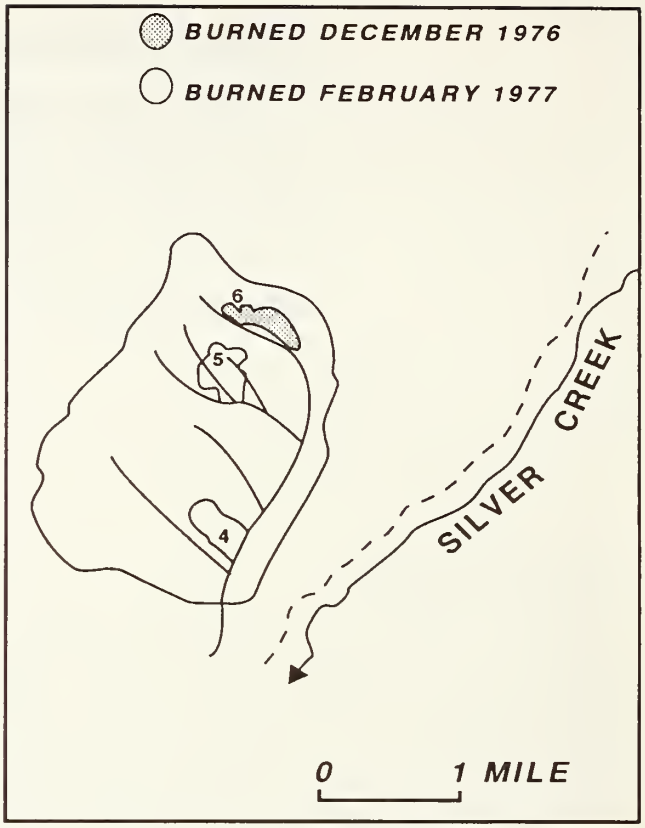

Figure 2—Location of cutting units within the Silver Creek Study Area.

h.t. normally consists of the low shrub *Spiraea betulifolia* with a layer of graminoids including *Calamagrostis rubescens* or *Carex geyeri* beneath the *Spiraea*. *Amelanchier alnifolia*, and *Salix scouleriana* are also common. In the *Pseudotsuga menziesii / Physocarpus malvaceus* h.t., the shrub *Physocarpus malvaceus* usually dominates the site. *Amelanchier alnifolia*, *Spiraea betulifolia*, and *Berberis repens* often occur. The *Pseudotsuga menziesii / Physocarpus malvaceus* h.t., which represents a warm, moist environment in the *Pseudotsuga menziesii* zone, is found most commonly on north aspects in central Idaho. However, it was found in Control Creek on south-facing slopes. In this case, it represents the dry extreme of the habitat type and the vegetation was similar to the vegetation in the *Pseudotsuga menziesii / Spiraea betulifolia* h.t., except for the presence of the *Physocarpus malvaceus*.

METHODS

Overmature stands of *Pinus ponderosa* and *Pseudotsuga menziesii* were logged and helicopter yarded during September through November 1976. Three cutting units designated 4, 5, and 6 were clearcut of all trees greater than 10 inches diameter breast high (d.b.h.). All smaller trees were left standing. Unit 4 is at the lower end of the drainage, unit 5 is halfway up the drainage, and unit 6 is near the top of the drainage (fig. 2). Unit 6 was accidentally burned in December 1976 while units 4 and 5 were prescribed burned in February 1977. When unit 6 burned, only 19 percent of the normal precipitation had fallen since September 1976, and weather conditions were unusually dry and warm. Though only 23 percent of the normal precipitation had fallen when units 4 and 5 burned, some snow was present on the ground. Using the Ryan and Noste (1985) fire severity rating, the burning resulted in a rating of 2-M for units 4 and 5 and 3-M for unit 6. Basal area for cutting units 4 and 5 was reduced 93 percent to 13 ft^2 per acre following the harvesting and burning (table 1). On unit 6, basal area was reduced 94 percent to 12 ft^2 per acre. The harvesting and burning treatment has resulted in an 80 times greater erosion rate for a 10-year period following the treatment compared to an undisturbed stand (Megahan 1988). The accelerated erosion has been attributed to the bare soil exposed by the burning rather than the helicopter yarding.

Sampling Procedure

Prior to the logging, in the summer of 1976, 12 permanent macroplots were located throughout the units with four plots (two of each habitat type) in each unit. Plots were situated on south or southwest aspects to evaluate

Table 1—Trees per acre by 4-inch diameter breast high (d.b.h.) classes and basal area per acre for *Pinus ponderosa* and *Pseudotsuga menziesii* in cutting units 4/5 and 6

	Trees per acre											
Unit and species	<4.5 ft	0-4	5-8	9-12	13-16	17-20	21-24	25-28	29-32	33-36	37-40	Basal area per acre
CUTTING UNIT 4/5												
Pinus ponderosa												
1976	1	167	15	20	9	9	11	4	3	1	1	126
1977	1	30	4	11								8
1978	3	24	4	11								8
1981	7	20	8	8								7
1986	8	21	7	7	1							8
Pseudotsuga menziesii												
1976	0	102	8	3	3	5	11	0	4	0	0	69
1977	1	19	11	3								5
1978	4	16	11	3								4
1981	13	16	9	3								4
1986	3	22	9	4								5
CUTTING UNIT 6												
Pinus ponderosa												
1976	0	57	11	11	0	5	3	11	5	0	0	96
1977	0	8	8	5								5
1978	0	8	5	5								5
1981	0	3	3	8								6
1986	0	3	3	3	5							8
Pseudotsuga menziesii												
1976	0	57	22	16	11	16	5	5	0	0	0	94
1977	0	30	19	3								7
1978	0	19	11	3								5
1981	46	13	11	3								4
1986	0	11	13	5								7

a "worst case" scenario for the treatment. Macroplots were 49 by 82 ft and were orientated with their long axis paralleling the contour (fig. 3). At intervals of 16 ft along the axis, perpendicular to the contour, two transects of 25 contiguous plots, 3.3 by 3.3 ft (miniplots), were located. Within each miniplot, an 8- by 20-inch plot (microplot) was established.

Microplot

Herbaceus vegetation (forbs and graminoids) was sampled in the microplots for frequency of rooted occurrence (rooted presence or absence) and canopy coverage (without regard to rooting). Precision for frequency resulted in a minimum interval of 2 percent. Canopy coverage was visually estimated in cover classes of T (0 to 0.5 percent of the plot); 1 (0.5 to 5 percent); 2 (5 to 25 percent); 3 (25 to 50 percent); 4 (50 to 75 percent); 5 (75 to 95 percent); and 6 (95 to 100 percent). Midpoint values for these classes are 0.2, 2.5, 15, 37.5, 62.5, 85, and 97.5 percent, respectively. Presence/absence tallies were used to

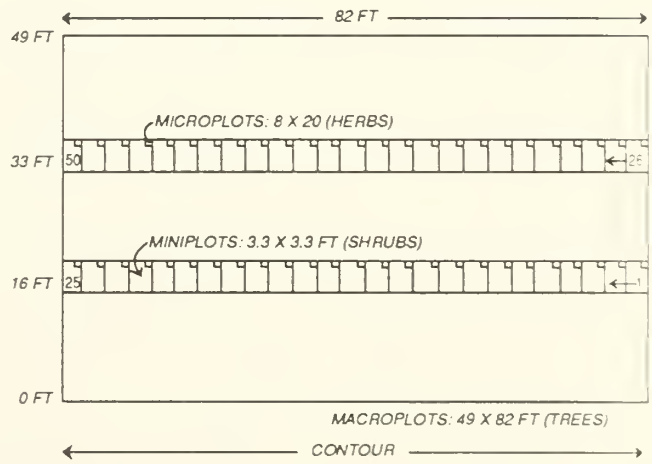

Figure 3—Plot layout for macroplot, miniplots, and microplots for the Silver Creek vegetation study.

determine frequency, which is the percentage of microplots in which a species occurs. Rooted frequency provides an indication of a plant species' rooted distribution or occurrence within the macroplot.

Miniplot

Shrub species were sampled in the miniplots for rooted frequency and canopy coverage using the same classes as for the microplots. Average height of each shrub species rooted within the plots was estimated to the nearest foot.

Macroplot

Trees and site features (percentage slope, aspect, elevation, slope position, and microrelief of the soil surface) were sampled in the macroplot. All trees greater than 4.5 ft tall were tallied by species in 4-inch d.b.h. classes to 40 inches as 0 to 4 inches, 5 to 8 inches, and so forth.

To assess the response of vegetation to helicopter logging and burning, five samplings were made over 10 years, from 1976 to 1986. These included predisturbance (1976) and 1-, 2-, 5-, and 10-year postdisturbance (1977 to 1986) remeasurements.

RESULTS AND DISCUSSION

Predisturbance vegetation on the 12 plots was similar, so results from the two habitat types are grouped. Within each macroplot, miniplots and microplots were designated as burned or unburned and are summarized separately. Over all three cutting units, 52 percent of the microplots were burned while 48 percent were unburned. Results from cutting units 4 and 5 are grouped based on the Ryan-Noste (1985) fire severity rating but are separate for cutting unit 6, which received a separate rating. Number of trees per acre and basal area per acre are summarized in table 1. Shrub cover, frequency, and height were summarized as well as forb cover and frequency. Results are shown tabularly and graphically for major species.

Trees

The overstory was dominated by *Pinus ponderosa* both before and after the disturbance (table 1). Some smaller trees not removed by the harvesting later died as a consequence of the broadcast burning, resulting in a decline in the number of trees per acre through time. Seedling recruitment into the stand was minimal. After 10 years only a few seedlings were found in the plots (table 1). In most cases, restocking by natural regeneration would be desired following helicopter logging. However, because of the prescription on this study area, no seedbearing trees were left in the cutting units and many of the trees adjacent to the plots were overmature and producing little seed.

Shrubs

The climax shrubs, *Physocarpus malvaceus* and *Spiraea betulifolia* were dominant in all three cutting units prior to the disturbance. Immediately following the disturbance, shrub cover (fig. 4, table 2) and root frequency (table 3) were lower on burned plots compared to unburned plots. However, the shrub composition was not altered. Total cover and frequency on cutting units 4/5, and the unburned plots in cutting unit 6, increased up to year 5, then declined at year 10 and in most cases were well below the predisturbance level. In cutting unit 6, total shrub cover and frequency on burned plots increased every sample year following the disturbance, but this was due primarily to an increase in *Ceanothus velutinus*.

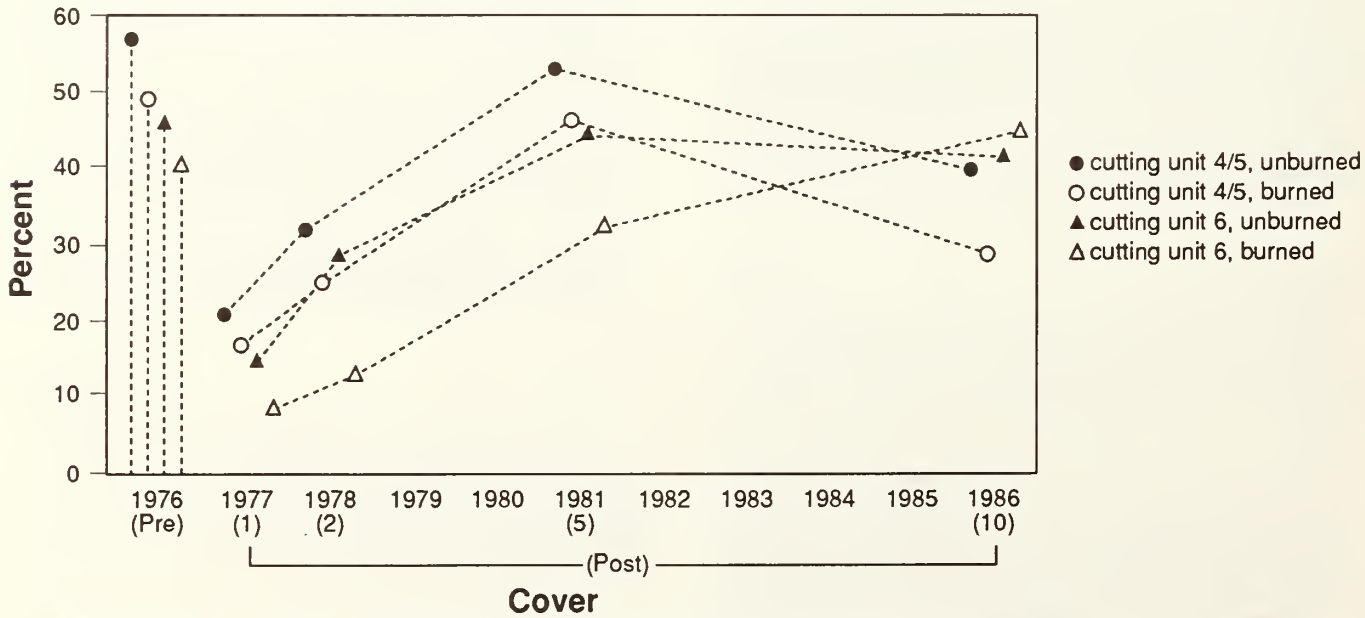

Figure 4—Cover (percent) of all shrubs in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

Table 2—Shrub cover (percent) by years for unburned and burned miniplots in cutting units 4/5 and 6

Species	Year	Unit 4/5		Unit 6	
		Unburned	Burned	Unburned	Burned
		Percent			
Amelanchier alnifolia	Pre[1]	1	1	0	1
	1	1	[2]1*	0	0
	2	1	1*	0	0
	5	2	1	1*	1*
	10	2	1	1	1*
Berberis repens	Pre	1*	1*	4	3
	1	1*	1*	1	1*
	2	1*	1*	2	1*
	5	1	1	2	1
	10	1	1*	2	2
Ceanothus velutinus	Pre	1	1*	0	2
	1	0	1	1	1
	2	1*	1	0	1
	5	1	1	1*	9
	10	1	4	1*	22
Physocarpus malvaceus	Pre	22	21	22	22
	1	8	6	7	3
	2	10	8	16	7
	5	17	17	27	14
	10	10	9	24	10
Prunus emarginata	Pre	1	1*	2	2
	1	1*	0	1	1*
	2	1	0	2	0
	5	1	1*	3	1*
	10	3	1	3	1*
Prunus virginiana	Pre	2	1	9	1
	1	1	1*	1	1*
	2	2	1*	2	1*
	5	2	1*	3	1*
	10	1	1	3	1*
Ribes spp.	Pre	1	0	0	0
	1	0	0	0	0
	2	1*	0	0	0
	5	1*	0	0	1*
	10	1*	0	1*	1*
Rosa spp.	Pre	2	1	2	2
	1	1	1*	1*	1*
	2	1	1*	1	1*
	5	1	1	3	1
	10	1	1	1	1
Salix scouleriana	Pre	4	0	1	1
	1	2	0	1	0
	2	3	0	1	1*
	5	5	1*	2	2
	10	8	1*	2	3
Spiraea betulifolia	Pre	20	21	4	6
	1	5	6	1	1
	2	10	12	3	1
	5	16	19	2	2
	10	7	7	3	3

(con.)

Table 2 (Con.)

Species	Year	Unit 4/5 Unburned	Unit 4/5 Burned	Unit 6 Unburned	Unit 6 Burned
		Percent			
Symphoricarpos albus	Pre	1	1	0	0
	1	1	1*	0	0
	2	1	1	0	0
	5	3	3	0	0
	10	3	3	0	0
Symphoricarpos oreophilus	Pre	1	1	1*	1*
	1	1	1	1*	1*
	2	1	1	1*	1*
	5	3	1	1	1
	10	2	1	1	1*
Total	Pre	57	49	45	40
	1	21	17	14	8
	2	32	25	28	12
	5	53	46	44	32
	10	40	29	41	44

[1]Pre is predisturbance, 1 is 1 year after disturbance, and so forth.
[2]1* is less than 1 percent.

Table 3—Root frequency (percent) of shrubs by years for unburned and burned miniplots in cutting units 4/5 and 6

Species	Year	Unit 4/5 Unburned	Unit 4/5 Burned	Unit 6 Unburned	Unit 6 Burned
		Percent			
Amelanchier alnifolia	Pre[1]	6	2	0	2
	1	6	2	0	1
	2	5	1	0	1
	5	5	3	0	1
	10	7	4	2	2
Berberis repens	Pre	4	6	37	27
	1	2	4	31	6
	2	2	3	30	12
	5	7	6	32	15
	10	7	8	38	17
Ceanothus velutinus	Pre	1	1	0	2
	1	[2]1*	6	0	27
	2	2	8	0	21
	5	2	5	0	28
	10	2	9	0	29
Physocarpus malvaceus	Pre	40	36	47	44
	1	40	30	47	30
	2	41	34	47	32
	5	44	36	49	36
	10	42	36	50	35
Prunus emarginata	Pre	1	1*	3	2
	1	1	0	3	1
	2	0	0	3	1
	5	2	1	3	1
	10	4	1	3	1

(con.)

Table 3 (Con.)

Species	Year	Unit 4/5 Unburned	Unit 4/5 Burned	Unit 6 Unburned	Unit 6 Burned
		Percent			
Prunus virginiana	Pre	10	10	30	10
	1	9	5	30	6
	2	9	6	22	8
	5	10	5	20	7
	10	8	6	20	5
Ribes spp.	Pre	1	1*	0	0
	1	0	0	0	0
	2	2	0	0	0
	5	2	0	0	1
	10	2	1	1	1
Rosa spp.	Pre	13	7	10	9
	1	13	4	10	5
	2	12	8	10	7
	5	14	10	10	8
	10	16	11	11	8
Salix scouleriana	Pre	6	0	1	1
	1	6	0	1	0
	2	5	0	1	0
	5	5	0	1	0
	10	5	1	1	1
Spiraea betulifolia	Pre	79	80	30	36
	1	77	71	37	23
	2	76	78	41	24
	5	84	85	33	28
	10	77	76	33	32
Symphoricarpos albus	Pre	9	9	0	0
	1	12	8	0	0
	2	13	9	0	0
	5	14	15	0	0
	10	18	20	0	0
Symphoricarpos oreophilus	Pre	2	2	2	2
	1	8	3	8	2
	2	6	3	4	3
	5	11	4	4	4
	10	10	4	9	2

[1]Pre is predisturbance, 1 is 1 year after disturbance, and so forth.
[2]1* is less than 1 percent.

At year 10, *Ceanothus* cover exceeded both *Physocarpus* and *Spiraea* cover on burned plots in cutting unit 6, while in unburned areas, and in all of cutting units 4/5, shrub composition after 10 years was similar to the predisturbance composition. The large decline in shrubs at 10 years is not understood but may be related to the extremely dry (half the normal precipitation) weather conditions the year of the sampling.

Ceanothus velutinus—This is an early seral, shade-intolerant shrub (Steele and Geier-Hayes 1986, 1987). It was present in the predisturbance shrub community in small amounts in all three cutting units. When burned and unburned plots were compared, *Ceanothus* was absent initially only on unburned plots in cutting unit 6 (fig. 5, table 3). Postdisturbance, *Ceanothus* cover and frequency barely increased on unburned plots in cutting units 4/5 and was never found rooted in unburned plots in cutting unit 6 (tables 2, 3). Cover and frequency of *Ceanothus* on burned plots in cutting units 4/5 increased slightly. However, increase of *Ceanothus* was dramatic in cutting unit 6 on burned plots. *Ceanothus* is a nonrhizomatous shrub that can survive burning (Stickney 1985) and will resprout from the root crown. *Ceanothus* can also germinate from seeds buried in the soil for as long as 200 to 250 years (Conard and others 1985). Seeds require

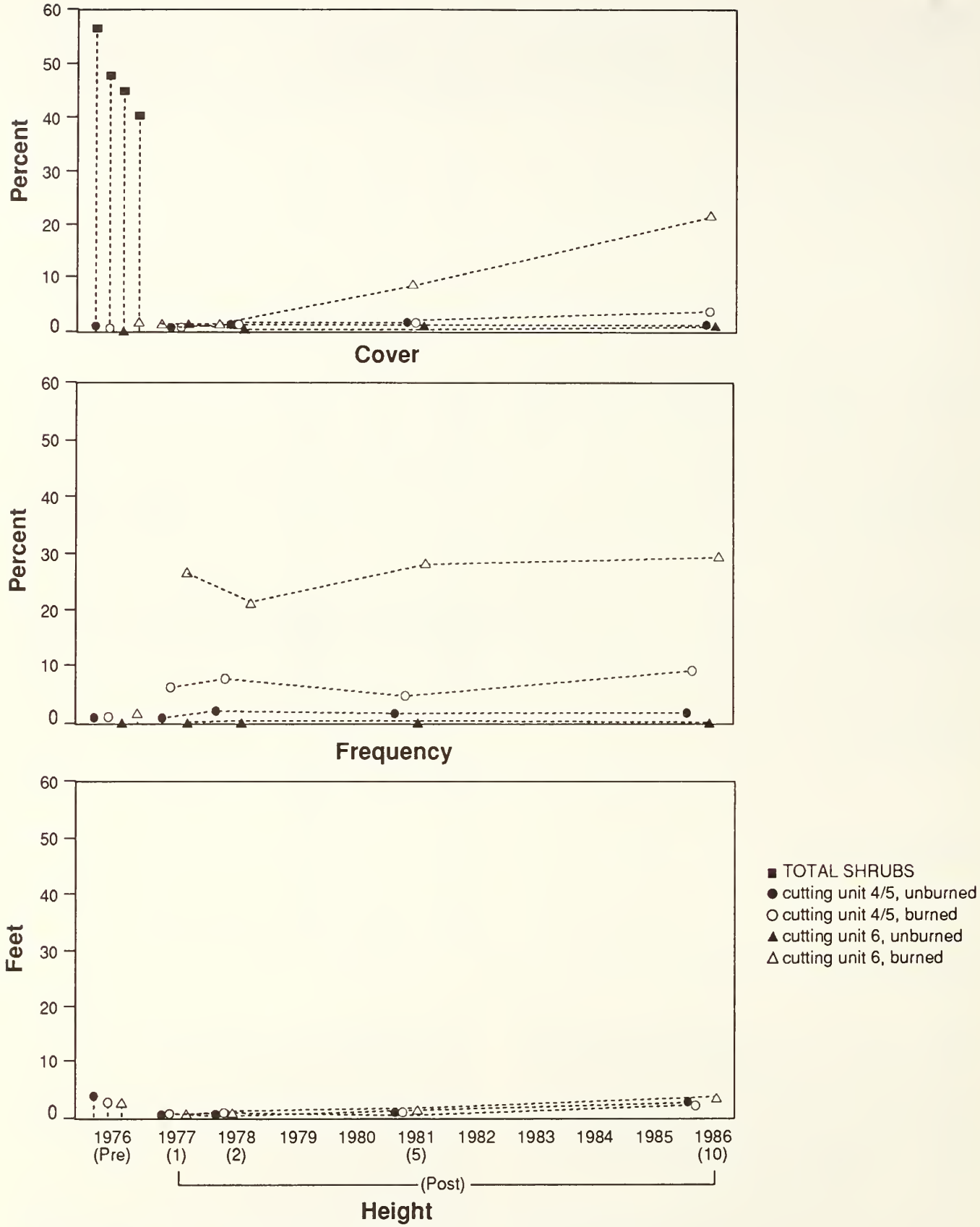

Figure 5—Cover (percent), frequency (percent), and height (feet) of *Ceanothus velutinus* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

others 1985). Seeds require heat to break dormancy, and burning often stimulates germination. Lack of germination in cutting units 4/5 may have been due to a lack of seed in the soil. However, presence of shrubs in the predisturbance community often indicates a seed source (Keane 1987). Low germination in cutting units 4/5 is more likely due to the lower severity burning, whereas in cutting unit 6, the burning appears to have been severe enough to trigger *Ceanothus* germination. Shrubs in cutting unit 6 were also taller than the predisturbance shrubs after 10 years, while those on cutting units 4/5 were shorter (table 4).

Physocarpus malvaceus—Cover and height of *Physocarpus* was the same on all cutting units before the disturbance (table 2, 4), though frequency was slightly higher in cutting unit 6 (table 3). Ten years after the disturbance, cover and frequency were not much different than the predisturbance on both burned and unburned plots in cutting units 4/5 (fig. 6). In cutting unit 6, however, cover, frequency, and height were increased on unburned plots after 10 years compared to the predisturbance even though cover peaked 5 years after the disturbance. In the burned plots in cutting unit 6, recovery was slower. Cover was only 64 percent of predisturbance level 5 years after the disturbance and 46 percent after 10 years. Frequency was 80 percent of the predisturbance frequency after 10 years.

Table 4—Height (feet) by years for shrubs in unburned and burned miniplots in cutting units 4/5 and unit 6

Species	Year	Unit 4/5		Unit 6	
		Unburned	Burned	Unburned	Burned
		Feet			
Amelanchier alnifolia	Pre[1]	2.9	2.9	0	3.2
	1	.9	1.0	0	1.6
	2	1.1	1.0	0	1.5
	5	1.8	2.1	0	1.3
	10	3.4	2.9	3.3	2.8
Berberis repens	Pre	.6	.5	.9	.9
	1	.4	.3	.7	.4
	2	.4	.4	.6	.5
	5	.4	.5	.5	.5
	10	1.1	1.1	.9	1.0
Ceanothus velutinus	Pre	4.1	3.1	0	3.1
	1	.7	.4	0	.3
	2	.6	.3	0	.3
	5	1.1	1.1	0	1.5
	10	3.2	2.6	0	4.2
Physocarpus malvaceus	Pre	2.4	2.5	2.1	2.3
	1	1.4	1.3	1.8	1.2
	2	1.6	1.4	1.6	1.3
	5	2.0	1.8	2.0	1.9
	10	2.5	2.4	3.1	2.9
Prunus emarginata	Pre	6.8	3.0	7.5	4.4
	1	2.0	0	3.1	1.0
	2	0	0	2.7	.5
	5	3.6	2.5	5.0	2.7
	10	3.7	3.8	6.1	4.4
Prunus virginiana	Pre	1.6	1.5	2.0	1.3
	1	1.0	.7	.7	.7
	2	1.0	.9	1.1	1.0
	5	1.4	1.5	1.6	1.3
	10	2.8	2.2	2.2	2.2
Ribes spp.	Pre	2.6	3.3	0	0
	1	0	0	0	0
	2	.9	0	0	0
	5	1.4	0	0	2.6
	10	1.9	.3	3.4	3.4

(con.)

Table 4 (Con.)

Species	Year	Unit 4/5		Unit 6	
		Unburned	Burned	Unburned	Burned
		Feet			
Rosa spp.	Pre	1.3	1.5	1.8	2.3
	1	.9	.9	.5	1.0
	2	.9	.9	.7	.8
	5	1.0	1.2	1.0	.9
	10	1.6	2.1	2.1	2.0
Salix scouleriana	Pre	6.8	0	6.6	8.0
	1	2.3	0	4.6	0
	2	3.8	0	2.8	0
	5	5.8	0	5.8	0
	10	6.9	5.1	6.5	9.8
Spiraea betulifolia	Pre	.9	.9	.7	.8
	1	.8	.8	.6	.6
	2	.7	.6	.7	.6
	5	.8	.8	.8	.7
	10	1.1	1.1	.9	1.1
Symphoricarpos albus	Pre	1.3	1.2	0	0
	1	.9	.9	0	0
	2	1.0	.7	0	0
	5	1.2	1.3	0	0
	10	1.7	1.6	0	0
Symphoricarpos oreophilus	Pre	1.9	2.5	1.6	1.2
	1	1.3	1.3	.5	.8
	2	1.3	1.1	1.0	1.0
	5	1.6	1.4	1.8	1.6
	10	2.2	2.3	2.3	1.6

[1]Pre is predisturbance, 1 is 1 year after disturbance, and so forth.

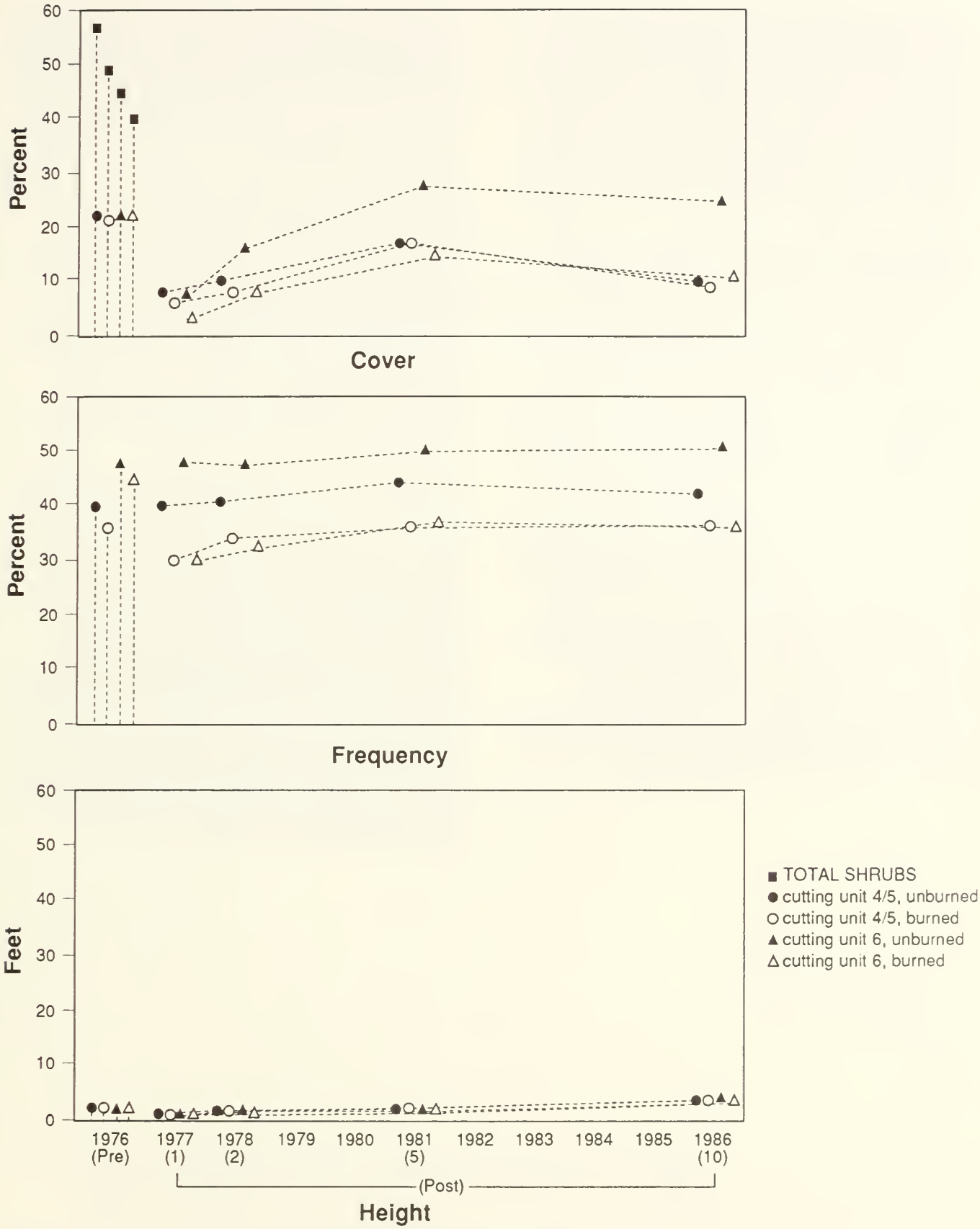

Figure 6—Cover (percent), frequency (percent), and height (feet) of *Physocarpus malvaceus* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

Physocarpus malvaceus is the climax shrub species in the *Pseudotsuga menziesii / Physocarpus malvaceus* habitat type and is capable of resprouting from root crowns after burning (Crane and others 1983). It spreads by way of root sprouts (Steele and Geier-Hayes 1987). Although the lower severity burning on cutting units 4 and 5 appears to have had little effect on *Physocarpus*, the higher severity burning on cutting unit 6 may have retarded the shrub. Arno and others (1985) noted a similar decline of *Physocarpus malvaceus* on dry sites in western Montana.

Spiraea betulifolia—This is the climax shrub in the *Pseudotsuga menziesii / Spiraea betulifolia* habitat type and is also common in the *Pseudotsuga menziesii / Physocarpus malvaceus* habitat type. Cover and frequency of *Spiraea* was much higher in cutting units 4/5 than in cutting unit 6 before the disturbance (tables 2, 4). There was little difference between the burned and unburned plots within each cutting unit both before the disturbance and 10 years later (fig. 7). Cover on cutting units 4/5 peaked 5 years after the disturbance when cover was 80 percent of the predisturbance level on unburned plots and 90 percent on burned. At 10 years, however, cover was only 35 percent of the predisturbance cover. This dramatic decline does not appear to be related to the disturbance. Frequency of *Spiraea* was not much different between burned and unburned plot after 10 years. In most cases, it was only slightly lower than predisturbance on all plots except the unburned plots in cutting unit 6, where frequency was slightly higher. As with cover, frequency peaked 5 years after the disturbance in cutting units 4/5. However, on unburned plots in cutting unit 6, frequency peaked 2 years after disturbance, and on burned plots, was highest at 10 years. *Spiraea* is a rhizomatous shrub that not only usually survives burning but can often flower the year immediately following burning (Crane and others 1983; Stickney 1985).

Symphoricarpos albus—This shade-tolerant, rhizomatous shrub is found primarily in the *Pseudotsuga menziesii / Physocarpus malvaceus* habitat type. It is uncommon in the *Pseudotsuga menziesii / Spiraea betulifolia* habitat type, though *Symphoricarpos oreophilus*, a nonrhizomatous shrub, is often present (table 3). *Symphoricarpos albus* is usually restricted to moist areas, even within the *Pseudotsuga menziesii / Physocarpus malvaceus* habitat type, and none was found in cutting unit 6, which is possible slightly drier due to its position in the drainage. In cutting units 4/5, there is no difference in the cover or height of *Symphoricarpos albus* on burned and unburned plots (tables 2, 4, fig. 8) . Cover before the disturbance and 10 years later was the same on burned and underburned plots, though cover had increased slightly after 10 years compared to the predisturbance cover. Frequency, however, increased dramatically over the predisturbance level on both burned and unburned plots though the spread was slightly slower on the burned plots. *Symphoricarpos albus* can survive burning and can spread following burning by way of its rhizomes.

Salix scouleriana—*Salix* was present in all cutting units before and after the disturbance, though none was present in cutting units 4/5 in the predisturbance plots which were burned (table 3). Following the disturbance, two seedlings were found on burned plots in cutting unit 4. Cover of *Salix* on unburned plots in cutting units 4/5 increased slightly, but there was little difference between burned and unburned plots in cutting unit 6 (table 2, fig. 9). *Salix*, a nonrhizomatous shrub, can attain heights as tall as 15 to 25 ft in the *Pseudotsuga menziesii / Physocarpus malvaceus* h.t. (Steele and Geier-Hayes 1987) and 10 to 14 ft in the *Pseudotsuga menziesii / Spiraea betulifolia* h.t. (Steele and Geier-Hayes 1986). However, in this study area the average height was 7 ft on all cutting units (table 4). It is capable of resprouting following burning (Stickney 1985) and can seed in moist mineral soil (Steele and Geier-Hayes 1986, 1987). In this study area, burning had little effect on the shrub.

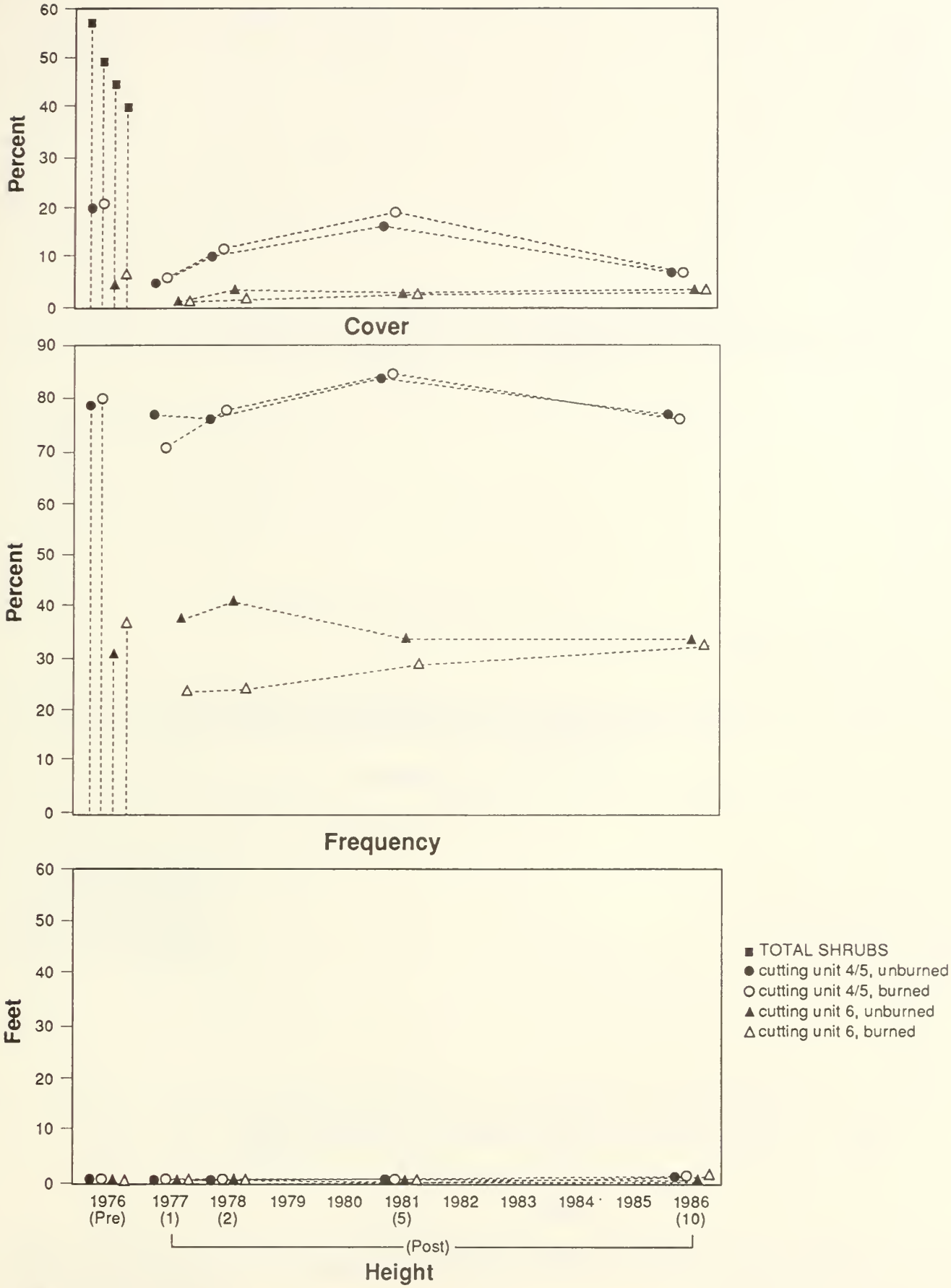

Figure 7—Cover (percent), frequency (percent), and height (feet) of *Spiraea betulifolia* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

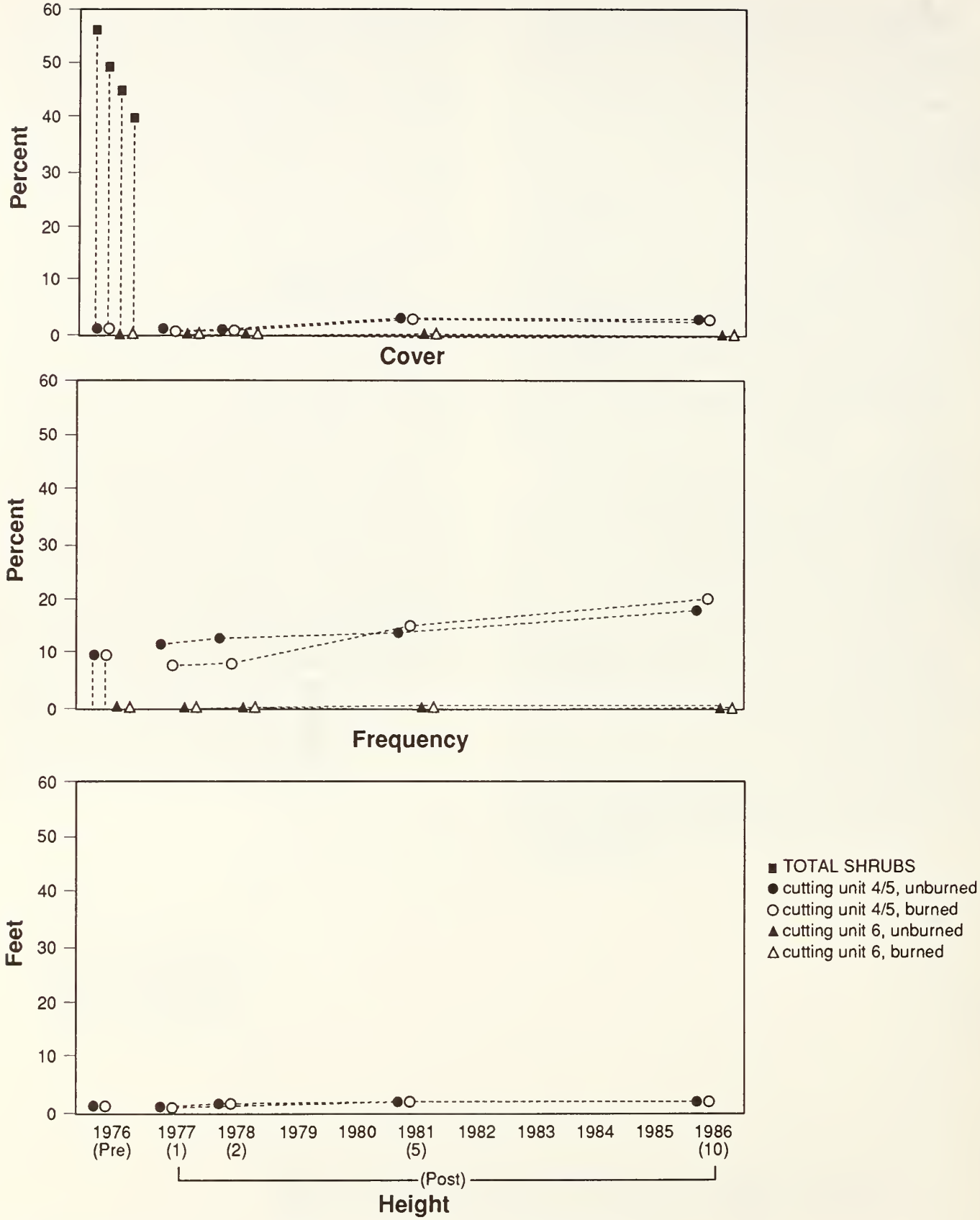

Figure 8—Cover (percent), frequency (percent), and height (feet) of *Symphoricarpos albus* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

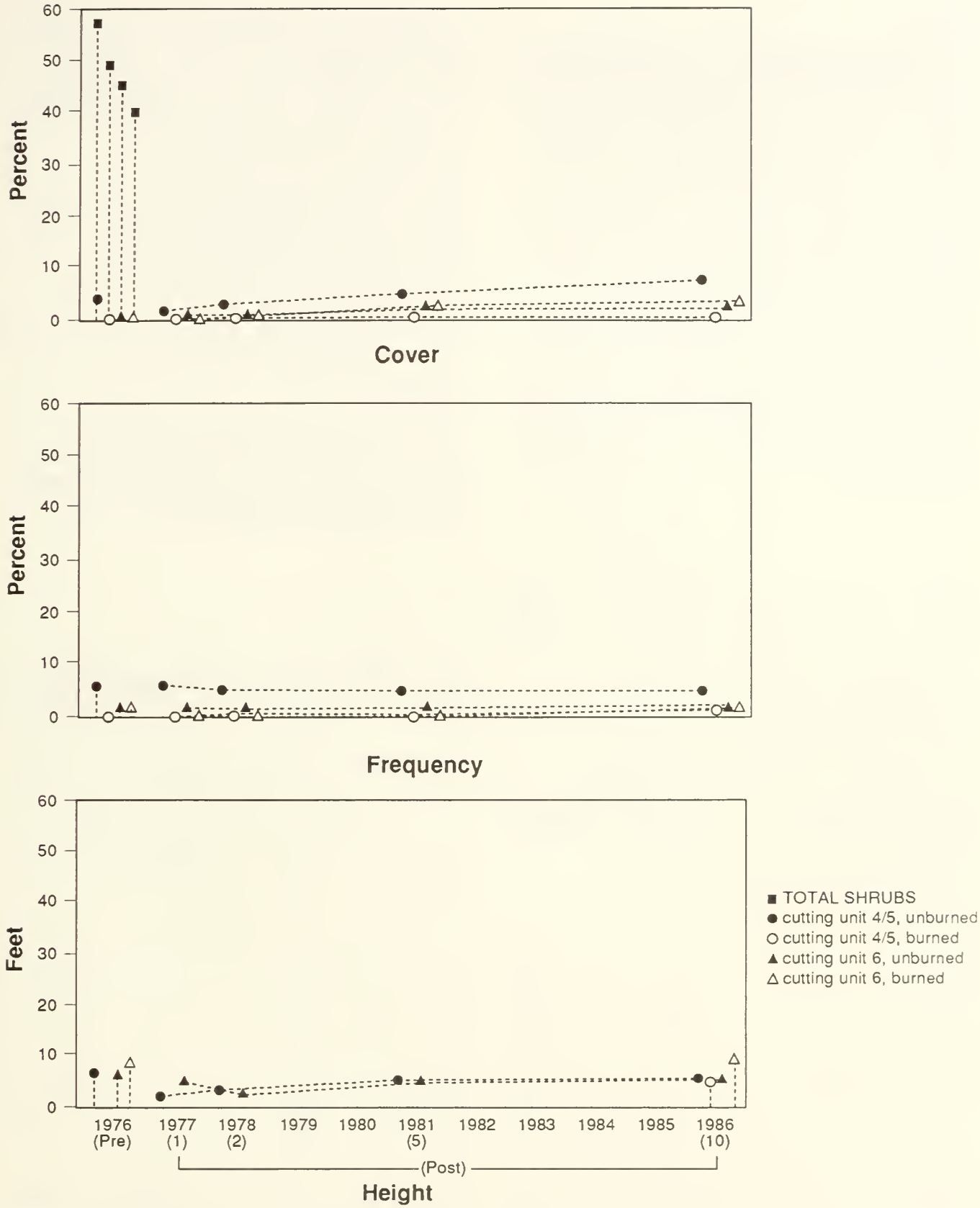

Figure 9—Cover (percent), frequency (percent), and height (feet) of *Salix scouleriana* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

Herbs

The predisturbance herbaceous community was dominated by the graminoids *Calamagrostis rubescens* and *Carex geyeri* and by the forb *Lathyrus nevadensis* (tables 5, 6). *Calamagrostis* was restricted to cutting units 4/5 while *Carex geyeri* was more common in cutting unit 6. Total cover of herbs (forbs and graminoids) was similar on burned and unburned plots within each cutting unit. However, total herb cover was higher in cutting units 4/5 than in cutting unit 6 (table 5, fig. 10). Total cover was not much different between burned and unburned plots on cutting units 4/5 after the disturbance. On cutting unit 6, at 10 years, total cover was nearly the same between burned and unburned plots, but recovery of herbs was slow. The year immediately following the burning, herb cover on unburned plots was 80 percent of the predisturbance cover, while on burned plots herb cover was only 50 percent of the predisturbance. At year 5, total cover on both burned and unburned plots exceeded predisturbance cover. However, total cover on unburned plots was 67 percent of the area compared to 43 percent cover on burned plots.

Composition of the herbaceous community was altered by the disturbance in most cutting units. Annuals, primarily species of *Collinsia, Cryptantha, Gayophytum, Clarkia*, and *Collomia* as well as the short-lived perennials such as *Phacelia*, will often occur on newly exposed mineral soil (Steele and Geier-Hayes 1986, 1987). Though annuals and short-lived perennials were found in the predisturbance community in only small amounts before the disturbance, they as a group began to attain high coverages immediately following the disturbance, particularly in cutting unit 6. By year 5, annuals and short-lived perennials were detected in every burned plot in cutting units 4/5 and in every plot in cutting unit 6 (table 6).

Though cover and frequency of annuals and short-lived perennials were low at year 10, this may have been due to the weather conditions because many annuals appear and flower early in the summer, and dry summer weather may have accelerated the loss before the sampling was conducted.

Herb cover for all cutting units was highest at year 5 when cover exceeded the predisturbance cover. Herb cover had declined at year 10. Again, the reason is not understood, but if drought were influencing the vegetation, the herbaceous vegetation is likely the most affected because much of its biomass is regrown each year.

Table 5—Herb cover (percent) by years for unburned and burned microplots in cutting units 4/5 and 6

Species	Year	Unit 4/5		Unit 6	
		Unburned	Burned	Unburned	Burned
Apocynum androsaemifolium	Pre[1]	1	1	1	1
	1	1	1	2	1
	2	[2]1*	1	1	1
	5	1	2	2	3
	10	1	2	1	2
Arenaria macrophylla	Pre	3	2	4	2
	1	1	2	1	1
	2	2	1	5	2
	5	2	1	7	1
	10	1*	1*	0	0
Arnica cordifolia	Pre	4	4	1	1
	1	2	3	1*	1
	2	5	5	1	2
	5	4	3	1	1
	10	0	0	0	0
Calamagrostis rubescens	Pre	13	13	0	0
	1	6	5	0	0
	2	17	12	0	0
	5	26	24	0	0
	10	8	8	0	0
Carex geyeri	Pre	3	4	10	10
	1	2	1	4	2
	2	4	4	12	5
	5	9	8	23	11
	10	10	7	15	9

(con.)

Table 5 (Con.)

Species	Year	Unit 4/5 Unburned	Unit 4/5 Burned	Unit 6 Unburned	Unit 6 Burned
Lathyrus nevadensis	Pre	12	14	4	4
	1	6	7	2	1
	2	9	7	3	1
	5	3	2	1	0
	10	1	1	1	1*
Thalictrum occidentale	Pre	3	1	0	1*
	1	1	1	0	0
	2	2	1	0	0
	5	3	1	0	0
	10	2	1*	0	0
Misc.	Pre	3	3	4	3
	1	4	1	3	2
	2	9	6	8	9
	5	10	9	6	4
	10	6	5	3	4
Annuals and short-lived perennials	Pre	0	1*	1	1*
	1	1*	1	8	3
	2	4	7	19	12
	5	10	17	27	23
	10	4	5	1	2
Totals	Pre	42	42	25	22
	1	23	22	20	11
	2	52	44	49	32
	5	68	67	67	43
	10	32	29	21	17

[1]Pre is predisturbance, 1 is 1 year after disturbance, and so forth.
[2]1* is less than 1 percent.

Table 6—Rooted frequency (percent) for herbs by years in unburned and burned microplots in cutting units 4/5 and 6

Species	Year	Unit 4/5 Unburned	Unit 4/5 Burned	Unit 6 Unburned	Unit 6 Burned
Apocynum androsaemifolium	Pre[1]	6	3	2	7
	1	5	7	1	3
	2	3	4	8	7
	5	7	8	18	17
	10	6	9	6	14
Arenaria macrophylla	Pre	23	21	31	22
	1	18	20	25	9
	2	27	16	41	17
	5	20	19	52	12
	10	6	4	0	0
Arnica cordifolia	Pre	25	17	5	7
	1	27	25	5	11
	2	47	37	5	15
	5	35	24	8	8
	10	0	1	0	0
Calamagrostis rubescens	Pre	46	43	0	0
	1	36	32	0	0
	2	43	30	0	0
	5	50	42	0	0
	10	39	39	0	0

(con.)

Table 6 (Con.)

Species	Year	Unit 4/5 Unburned	Unit 4/5 Burned	Unit 6 Unburned	Unit 6 Burned
Carex geyeri	Pre	11	13	36	33
	1	9	4	30	15
	2	8	12	32	13
	5	18	16	38	19
	10	20	10	32	22
Lathyrus nevadensis	Pre	53	59	29	25
	1	52	48	27	11
	2	59	52	22	12
	5	34	17	7	6
	10	23	18	8	2
Thalictrum occidentale	Pre	9	4	0	2
	1	6	5	0	0
	2	8	4	0	0
	5	8	4	0	0
	10	10	6	0	0
Misc.	Pre	10	10	8	0
	1	8	1	8	4
	2	36	25	14	7
	5	23	18	24	13
	10	10	14	13	1
Annuals and short lived perennials	Pre	8	0	0	1
	1	5	9	25	15
	2	34	40	49	52
	5	61	100	100	100
	10	55	79	34	33

[1]Pre is predisturbance, 1 is 1 year after disturbance, and so forth.

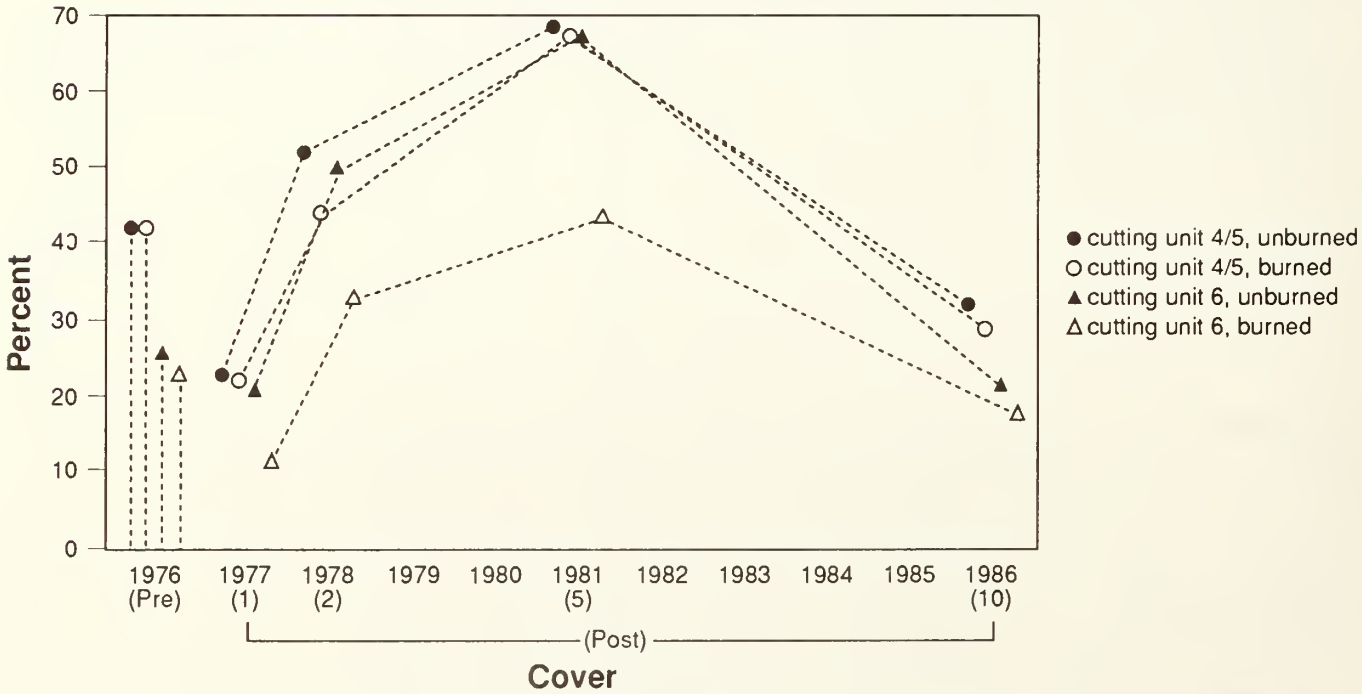

Figure 10—Cover (percent) of all herbs in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

Calamagrostis rubescens—This was the dominant graminoid in cutting units 4/5 in the predisturbance community. None was found in cutting unit 6 (tables 5, 6). Cover on burned and unburned plots after the disturbance was only slightly different. At years 5 and 10 the cover was nearly the same on both burned and unburned areas (table 5, fig. 11). Frequency and cover of *Calamagrostis* was highest in year 5 and much lower in year 10. The decline does not seem related to the disturbance. *Calamagrostis rubescens* is a rhizomatous grass that can usually survive burning (Crane and others 1983; Stickney 1985). Both Crane and others (1983) and Stickney (1985) found *Calamagrostis* blooming the year immediately following burning on their study areas.

Carex geyeri—This was present in small amounts in cutting units 4/5 and was the dominant graminoid in cutting unit 6 (tables 5, 6). While there was little difference in cover of *Carex* on burned and unburned plots in cutting units 4/5, larger cover increases of *Carex* occurred on unburned plots compared to burned plots in cutting unit 6 (table 5, fig. 12).

The cover in the predisturbance community was the same, but cover on burned plots was only half the cover on unburned plots the year immediately following the burning, 2 years later, and 5 years later. At 10 years, cover on burned plots was 60 percent of the unburned plots. Frequency of *Carex geyeri* immediately following the disturbance was also about half of the unburned plots following the disturbance, though in the predisturbance community frequency was nearly the same (table 6).

Carex geyeri has an extensive root system, but the root crowns are close to the soil surface. The burning in cutting unit 6 may have heated the soil enough to damage or destroy the root crowns, which then retarded the regrowth. In cutting units 4/5, the less severe burning does not appear to have had the same effect on the *Carex*.

Lathyrus nevadensis—This was the dominant forb iin all three cutting units before the disturbance, though coverages were higher in cutting units 4/5 (tables 5, 6). The year immediately following the disturbance, cover was half that of predisturbance on both burned and unburned plots in all three cutting units (table 5, fig. 13). Frequency, however, barely changed the year following the disturbance on unburned plots in cutting units 4/5 and actually increased in unburned plots in cutting unit 6 (table 6). On burned plots in cutting units 4/5, frequency declined only slightly. However, on burned plots in cutting unit 6, frequency was only half that of predisturbance. Cover increased slightly on unburned plots in all cutting units by the second year following the disturbance, but cover on all plots then declined by year 5 and was even lower by year 10. The trend was similar for frequency; on many plots, frequency peaked after 2 years, then declined at years 5 and 10.

When present, *Lathyrus* is usually found in the near-climax community (Steele and Geier-Hayes 1987). A shade-tolerant forb, it may not be capable of sustaining high coverages under the extreme environmental conditions created by clearcutting. Even though the total cover of shrubs increased each year to year 5 following the disturbance, loss of overstory usually results in increased amounts of solar radiation and heating on the site even with the shrub cover.

Arnica cordifolia—This was present in all three cutting units (table 6), but had higher coverages in cutting units 4/5 (table 5). Though cover was small, frequencies were high. The pattern of change through time was similar to *Lathyrus*; cover and frequency of *Arnica* increased up to 2 years following the disturbance, then began to decline (fig. 14). Like *Lathyrus*, *Arnica* often attains highest coverages in late seral communities (Steele and Geier-Hayes 1987), though it can also be present in early seral communities.

CONCLUSIONS

The severity of the burning in cutting units 4/5 rated a 2-M using the Ryan-Noste (1985) fire severity rating, while the burning in cutting unit 6 attained a 3-M. Burning in cutting units 4/5 took place spring 1977 with some snow present on the site, while the burning in cutting unit 6 took place in winter 1976, before any snow had fallen. Recovery of vegetation on burned and unburned areas in cutting units 4/5 was similar, and after 10 years, vegetation in both burned and unburned plots was almost the same. In cutting unit 6, however, vegetation differed between burned and unburned plots. In the unburned areas, the vegetation resembled that found on plots in cutting units 4/5. But on burned plots, after 10 years the vegetation was dominated by *Ceanothus velutinus*.

Most vegetation in the area before the disturbance resprouted following the harvesting and burning. *Physocarpus malvaceus* and *Spiraea betulifolia* dominated the vegetation before the disturbance, and both were still prominent on burned/unburned plots in cutting units 4/5, and in unburned plots in cutting unit 6. In burned plots in cutting unit 6, *Ceanothus velutinus* dominated after 10 years. The only shrub other than *Ceanothus* that increased on the study area was *Symphoricarpos albus*, which increased in frequency in cutting units 4/5. Over the 10 years, many shrubs peaked in cover and frequency 5 years after the disturbance. However, this peak may be related to the weather conditions the summer of the sampling rather than to the disturbance.

Recovery of *Physocarpus malvaceus* was slow on the burned plots in cutting unit 6 compared to the unburned plots in unit 6 and to both burned and unburned plots in cutting units 4/5. The *Physocarpus malvaceus* may have been retarded by the higher soil heating that took place in cutting unit 6. No other shrubs present before the disturbance were affected like *Physocarpus*, but the burning was hot enough to stimulate the germination of *Ceanothus*, which did not attain high coverages in the other cutting units.

As with the shrubs, many of the herbs present before the disturbance resprouted following the burning. Annuals increased on many plots, both burned and unburned. However, their individual coverages are small even though annuals were found on almost every plot in the study area at year 5. *Calamagrostis rubescens* and *Carex geyeri*, both graminoids, were the dominant herbs in the

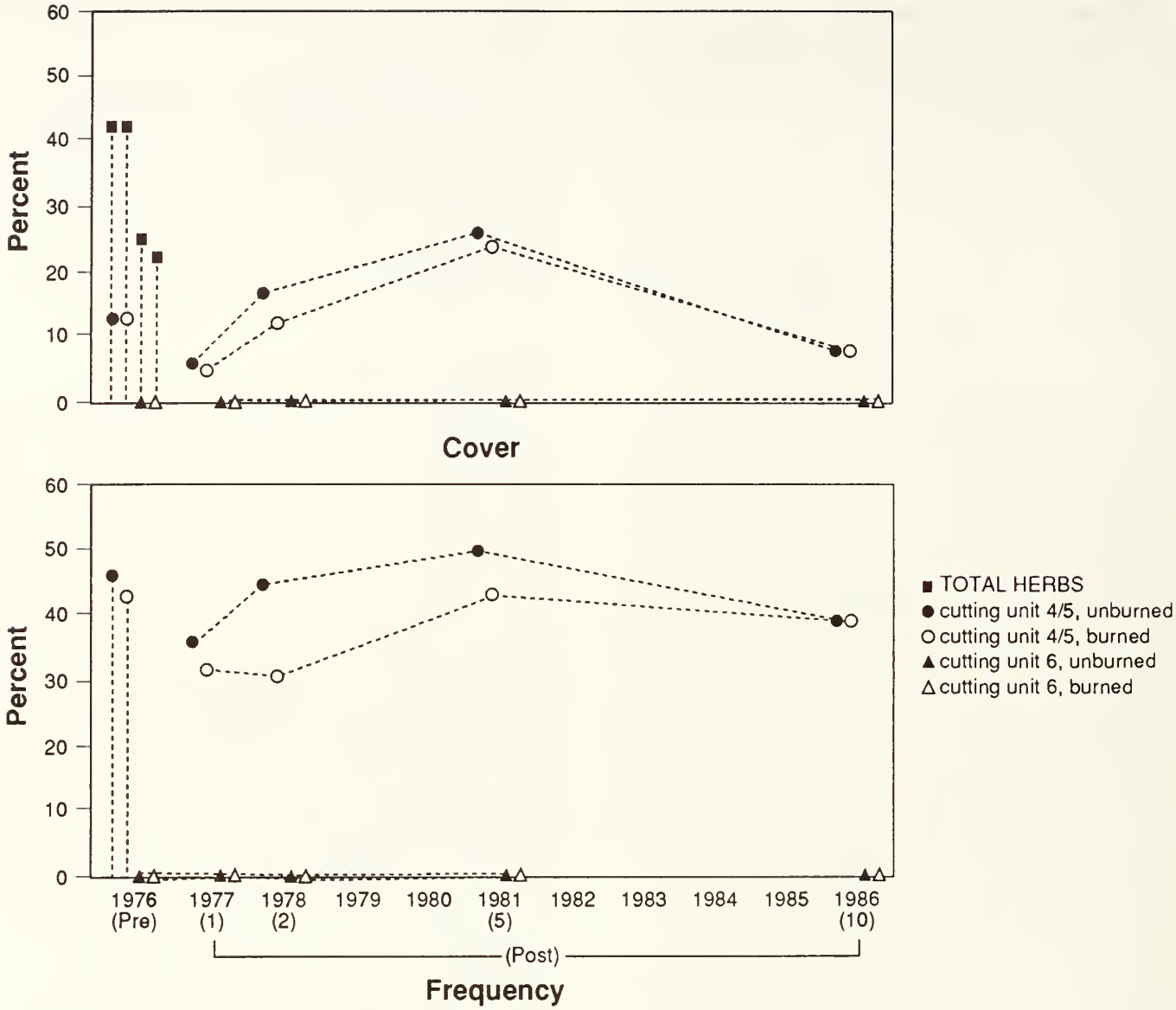

Figure 11—Cover (percent) and frequency (percent) of *Calamagrostis rubescens* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

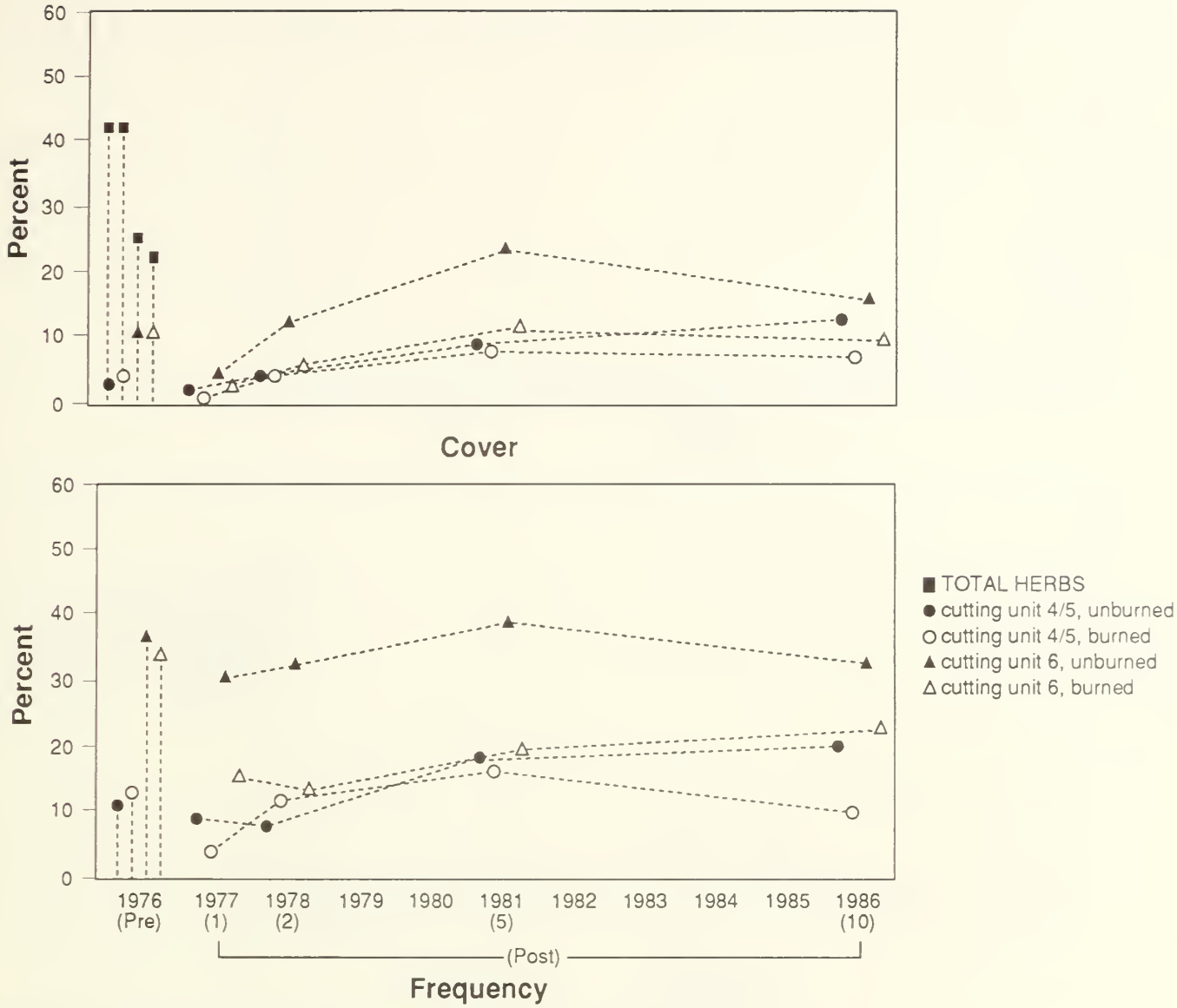

Figure 12—Cover (percent) and frequency (percent) of *Carex geyeri* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

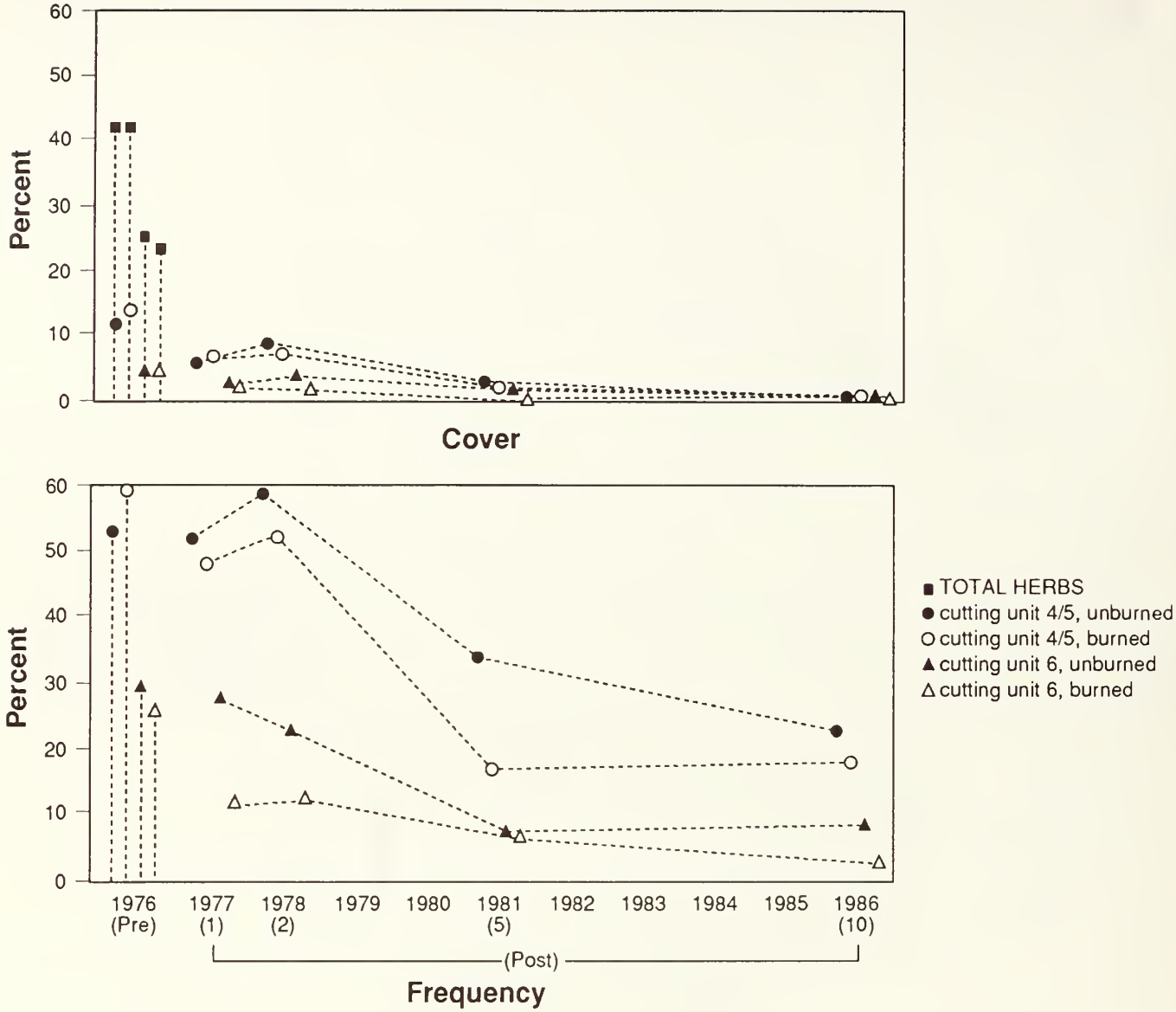

Figure 13—Cover (percent) and frequency (percent) of *Lathyrus nevadensis* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

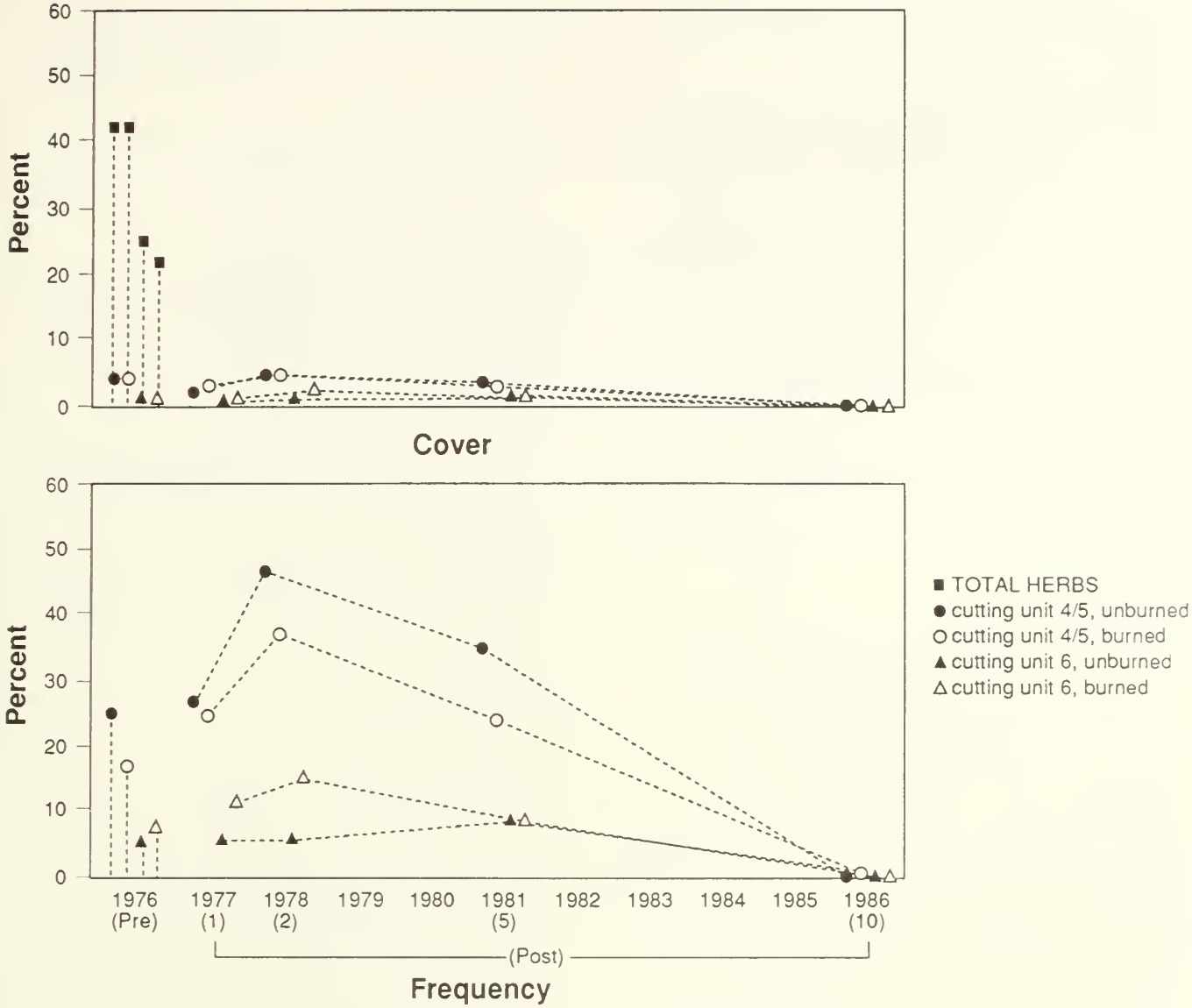

Figure 14—Cover (percent) and frequency (percent) of *Arnica cordifolia* in unburned and burned plots in cutting units 4/5 and 6 predisturbance (pre) and postdisturbance, (1), (2), (5), and (10) years after disturbance.

study area both before, and after the disturbance. The dominant forbs were *Lathyrus nevadensis* and *Arnica cordifolia*.

Many of the herbs, as with the shrubs, increased to year 5, then declined, though as with the shrubs, this was probably related to the weather conditions. Only *Lathyrus* and *Arnica* appear to have been affected by the treatment. Both peaked the second year following the disturbance, after which both cover and frequency declined. The sites may now be too exposed by the removal of the tree cover to maintain high coverages of these two herbs, both of which are often found in near climax communities.

Carex geyeri, like *Physocarpus*, may have been affected by the higher severity burning in cutting unit 6. In most cases, herbs responded similarly on burned and unburned plots in all cutting units. However, *Carex geyeri* on burned plots in cutting unit 6 was slower to reestablish. After 10 years, cover of *Carex* was only half the cover on unburned plots. Like *Physocarpus*, the *Carex* appears to have been affected by the more severe burning in cutting unit 6.

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Shrub frequency, cover, and height, and herb frequency and cover were measured on plots from two Douglas-fir habitat types in three cutting units. The plots were measured prior to helicopter yarding and broadcast burning and then 1, 2, 5, and 10 years later. The broadcast burning was more severe on one cutting unit than the other two. Vegetation was essentially the same on unburned and burned plots in the less severely burned cutting unit both before and after the treatment. However, the vegetation was altered on the more severely burned plots.

KEYWORDS: shrubs, herbs, frequency, cover, height.

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